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17 December, 1999

Magalie Roman Salas
Office of the Secretary
Federal Communications Commission
445 12th Street, S.W., Counter TWA 325
Washington, D.C. 20554

Dear Ms. Salas:

The attached comments are being submitted for consideration on the matter of ET Docket 99-231.

Respectfully,

T R Bourk

Terrance R. Bourk

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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Amendment of Part 15 of the	)	ET Docket 99-231
Commissions Rules Regarding	)	
Spread Spectrum Devices	)	

COMMENTS

I. INTRODUCTION

Silicon Wave, Inc., San Diego, CA is a member of the Bluetooth Special Interest Group (SIG) and the HomeRF Working Group and we hereby submit comments to oppose the amendments proposed in the FCCs Notice of Proposed Rulemaking (NPRM) regarding the operation of non-licensed spread spectrum systems.

II. OVERVIEW

What the Commission should conclude from the letters in favor of this change is that many individuals and companies believe that radio bandwidth should be allocated for higher data rate services. We at Silicon Wave believe that many of these respondents do not understand the negative implications for the existing systems and services designed and operating in the 2.4 GHz ISM band.

Does the industry and the public need higher bandwidth wireless services? Absolutely!

Can we have 5 and 10 Mbps wireless capability for the same power, cost and size as 1 Mbps or lower data rates such that these new services can drop into the many applications invoked in the comments from CUBE. No!

Should the rules for the 2.4 GHz ISM band be modified to allow wider bandwidth frequency hopped designs? Only if the allowed power levels are reduced sufficiently to compensate for the increased interference that results from these signals. We must ensure that these new systems do not pose higher levels of interference in a band that has existing products (such as 802.11) and has a looming plethora of products based on the Bluetooth specification.

What power level would be fair for such 3 and 5 MHz bandwidth carriers? As we said in our earlier submission it is much more than the proposed 5 and 7 dB reductions. As we will show with our simulations and measurements, the additional backoff in maximum power level is at least 5dB and is probably closer to 20 dB. This would mean a total backoff of 10 to 25 dB for the 3 MHz carriers and 17 to 27 dB for the 5 MHz carriers. The resulting maximum transmit powers would then be 15 to 20 dBm for 3 MHz carriers and 3 to 13 dB for the 5MHz carriers.

III. INCORRECT IMPRESSIONS FROM CUBE

In the analysis that was submitted by the Committee for Unlicensed Broadband Enablement ("CUBE") dated November 19, 1999, our earlier submission was characterized as "virtually identical" to that submitted by several other Bluetooth Special Interest Group members. The similarity was because we agreed with the letter that was provided to the Bluetooth supporters. Our submission was not identical. We call attention to comment III. f) which we reproduce here.

"Existing FH systems like Bluetooth have been designed to be low cost and extremely battery efficient through the use of FSK modulation and low transmit powers of 0 or 20 dBm. FSK modulation is unusually sensitive to energy at the edge of the receiver bandwidth due to an inherent squared term in the frequency deviation term of FM demodulators. The slower roll-off in energy that would result from the proposed 3 or 5 MHz bandwidth will have an impact that is difficult to predict without careful analysis, complex modeling of the distribution and operating parameters of the different kinds of units and empirical confirmation from field testing. Only through the careful study of such data could we arrive at a fair recommendation of the required power level backoff for these WBFH signals. The cost of such an effort for the FCC and the companies involved would be an undue burden."

An adequate study of the interference impact is a significant effort. The data we in this submission present shows that the likely outcome of such a study would be a significant reduction in the maximum transmit power level of WBFH devices. Thus in the end the physics of the situation will preclude meeting the commercial expectations. This proposal seems to be a futile effort to obtain a capability that needs to be addressed in a different frequency band.

IV. ADDITIONAL DATA

The attached report summarizes results from internal simulation studies that were done as a part of the design of ISM band receivers. We also present lab measurements that were performed in the interim to confirm our simulation results on interference and some specifically to address the question of WBFH signals. We were able to generate an FSK carrier with a 3 MHz bandwidth and use this to test the sensitivity of a Bluetooth receiver to interference from such a signal.

The simulation and measurement results confirm the simulation study provided by Intersil.

Respectfully submitted,

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Appendix 1

Effects of 3Mbps Data Interference on a Bluetooth Receiver

1. Scope

In response to the proposed changes to the 2.4 GHz ISM band, we have prepared this report summarizing simulation and measurement results that document the impact of signals with bandwidth wider than the allowed 1 MHz frequency hopped carriers. The interference caused in a Bluetooth receiver was examined for narrower and wider carriers. The narrow carriers were pure tones. The wider carriers were 3 MHz 20 dB bandwidth data signals with digital modulation of GFSK with BT = 0.5, h = 0.32 (i.e. modulation index).

2. Introduction.

Internal studies undertaken while designing the demodulator for the Bluetooth receiver, examined the performance of a FM demodulator in the presence of tonal interference. Due to the Gaussian shape of the modulated signal, the results indicate that the demodulator is particularly sensitive to noise at the band edge. In fact the results show that the Bluetooth modulation is 12 dB more sensitive to tones offset 500 kHz from the center of the desired signal when compared to interfering tones at the center of the desired signal.

It is well known by analog/broadcast FM receiver designers that FM signals suffer a 6dB/octave roll off in signal-to-noise ratio. Hence the reason for pre-emphasis in the transmitter and de-emphasis in the receiver.

In most data systems, however, pre-emphasis is not used as this would violate the spectral occupancy. Hence the system is more prone to interference at the band edges than at the center of the channel. Therefore the best case interfering signal is one that has exactly the same power spectral density as the wanted signal. The worse case signal would be one that has a power spectral density that is non-uniform and is stronger at the band edges. This is typically the case with an adjacent channel interfering signal.

3. Simulated Interference results

The following observations are based on a simulation that models a Bluetooth receiver from antenna to digital data output.

3.1 Bluetooth Adjacent Channel Signal

Figure 1 shows a desired, 1 MHz bandwidth carrier centered at 2.4 GHz and with a total power of –60 dBm. This carrier conforms the Bluetooth modulation and filtering characteristics. An interfering carrier of similar characteristics was introduced in the adjacent channel and the level adjusted until the bit error rate (BER) in the demodulated, desired signal reached the criterion level of 0.001 or 0.1% BER. The resulting adjacent channel signal had to be at total power level of –58 dBm. This is equivalent to a C/I of –2 dB.

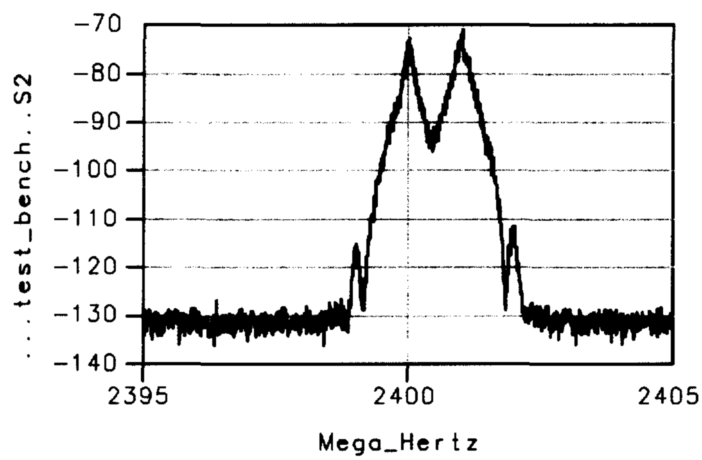

Figure 1: Combined spectrum of the wanted and interfering signals. The desired signal (at –60 dBm) is on the left and the interfering signal (at –58 dBm) is on the right (C/I = -2dB). The criterion in the receiver was bit error rate of 0.001.

3.2 Comparative effect of a 3MHz Adjacent channel signal

Using the same desired signal as postulated in section 3.1 above, we replaced the interfering carrier with one with a 3 MHz bandwidth. The level of the interferer was then adjusted until the reception of the desired signal again degraded to a BER of 0.001. The power of this 3 MHz signal had to be lowered until the C/I was 9 dB. The resulting signals are shown in Figure 2.

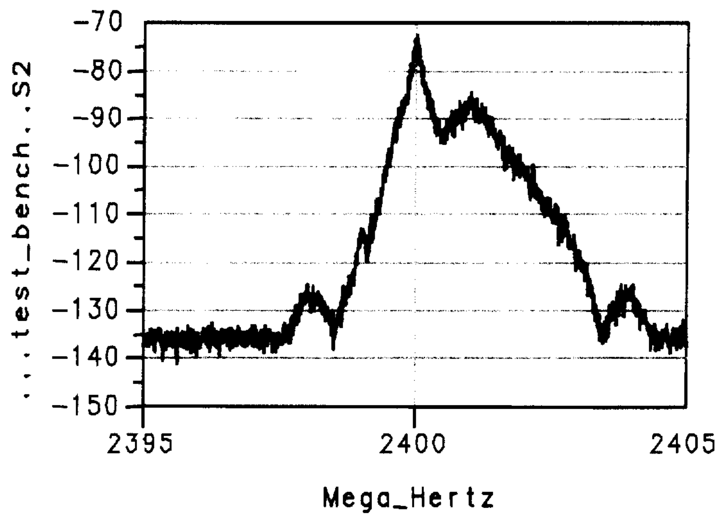

Figure 2: The combined spectrum of the wanted and interfering signals. The desired signal (at –60 dBm) is on the left and the interfering signal (at –69 dBm) is on the right (C/I= 9dB). The criterion in the receiver was bit error rate of 0.001.

It should be noted that the same receiver performance is achieved when the power spectral density of the 3 Mbps data signal intersects with the desired Bluetooth signal at virtually the same power spectral density value as occurs with the 1 MHz interferer. This seems to be a general observation from many simulation cases examined.

3.3 Co-channel response with a 3 MHz interfering signal

In this case the co-channel interfering signal is the 3 MHz signal defined previously. With the 3 MHz interfering signal, a C/I of 13 dB was required to achieve a BER of 0.2%. With a Bluetooth interfering signal, a C/I of 9 dB was required to achieve a BER of 0.1%. The drop in performance is due to the power spectral density difference between the 3 MHz signal and the Bluetooth signal.

4. Measured Performance

The same tests were performed on a Bluetooth direct conversion receiver. As well as measuring the BER of the signal, the baseband signal was observed on a HP 89410A. The HP89410A was in 'I + jQ' mode, hence the middle of the screen shown in Figure 3 is dc. Figure 3 illustrates the difference in power spectral density of the Bluetooth signal (1Mbps, BT=0.5, h=0.32 GFSK) and a 3 Mbps signal (3Mbps, BT=0.5, h=0.32 GFSK).

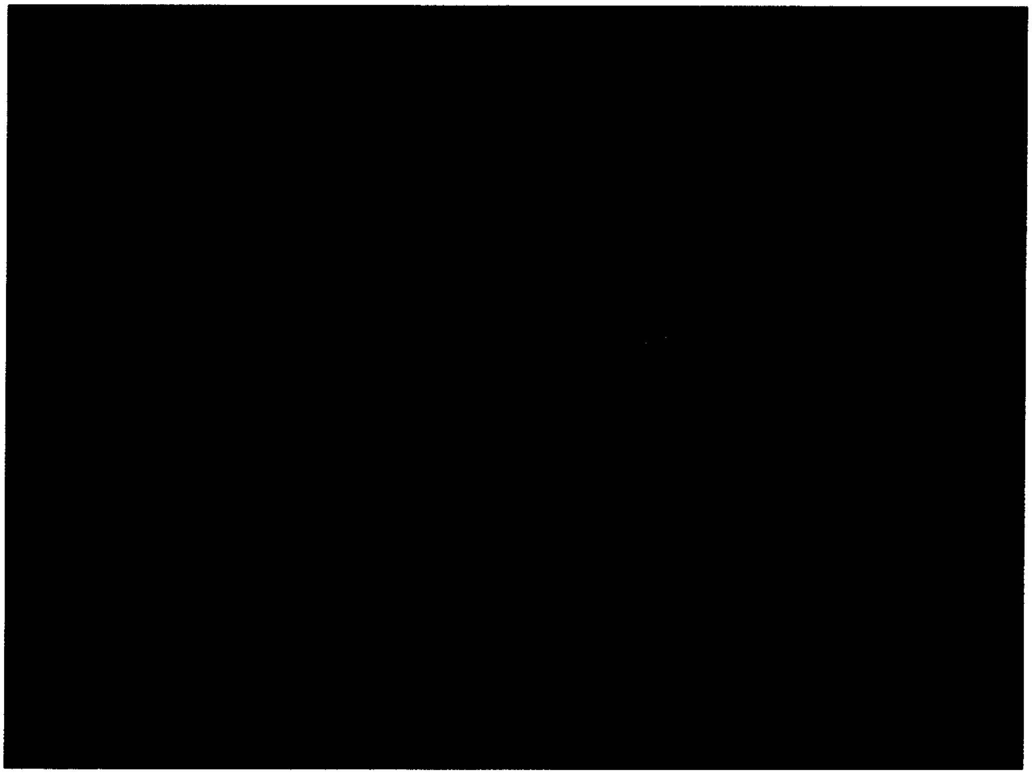

Figure 3: The comparative power spectral density of a Bluetooth signal versus a 3 Mbps signal with the same total power (-60 dBm into the receiver). Note the difference in power of the two signals at a 500 kHz offset (near the vertical line to the right of center)

With the two signals as illustrated in Figure 3, the interference levels for co-channel, adjacent channel (desired +/- 1MHz) and alternate channel (desired +/- 2MHz) were measured. In all cases a Bluetooth signal at an RF frequency of 2.432GHz and power level of –60 dBm into the receiver. This are same conditions required by the Bluetooth specification for these measurements. Using a calibrated setup the interfering signal was combined with the wanted Bluetooth signal. The level and the frequency of the interfering signal was adjusted according to the required measurement.

5. Summary of simulated and measured results.

The simulated and measured data was taken while the receiver maintained a BER of 0.001 on the desired signal.

	Simulation		Measurement	
Type of Interference	Bluetooth signal	3Mbps signal	Bluetooth signal	3Mbps signal
Co-channel C/I (dB)	9	13	10	14
Adjacent channel C/I (dB)	-2	9	-3	10
Alternate Channel C/I (dB)	-32	-9	-38	-10

6. Conclusions

The interference performance is very dependent on the power spectral density of the interfering signal compared with the wanted signal. FSK is more prone to interference or noise that resides at the edge of the channel.

Figure 3 clearly shows that a 3Mbps signal, with the same total power, has significantly more energy at the band edges than a 1 MHz bandwidth signal such as used in Bluetooth. Hence it makes sense that this wide band signal is going to cause more interference in a Bluetooth receiver than a similar, 1 MHz bandwidth interfering carrier. This is clearly seen in our simulations and measured results. A 3 Mbps data signal would have to backed off by 4 to 5 dB to produce similar interference on a co-channel 1 MHz, Bluetooth signal.

For a 3 Mbps data signal centered on the alternate channel (2 MHz offset) the 3 Mbps signal would have be **more than 20 dB** less powerful than a 1 MHz Bluetooth signal to produce a similar level of interference. This reduction in power would have to be added to the proposed backoff factors (5dB for 3 MHz and 7dB for 5 MHz carriers) to yield the required maximum RF power so that such WBFH carriers would produce similar levels of interference in the 2.4 GHz ISM band.